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Review of Progress in JRC Bioeconomic Modelling

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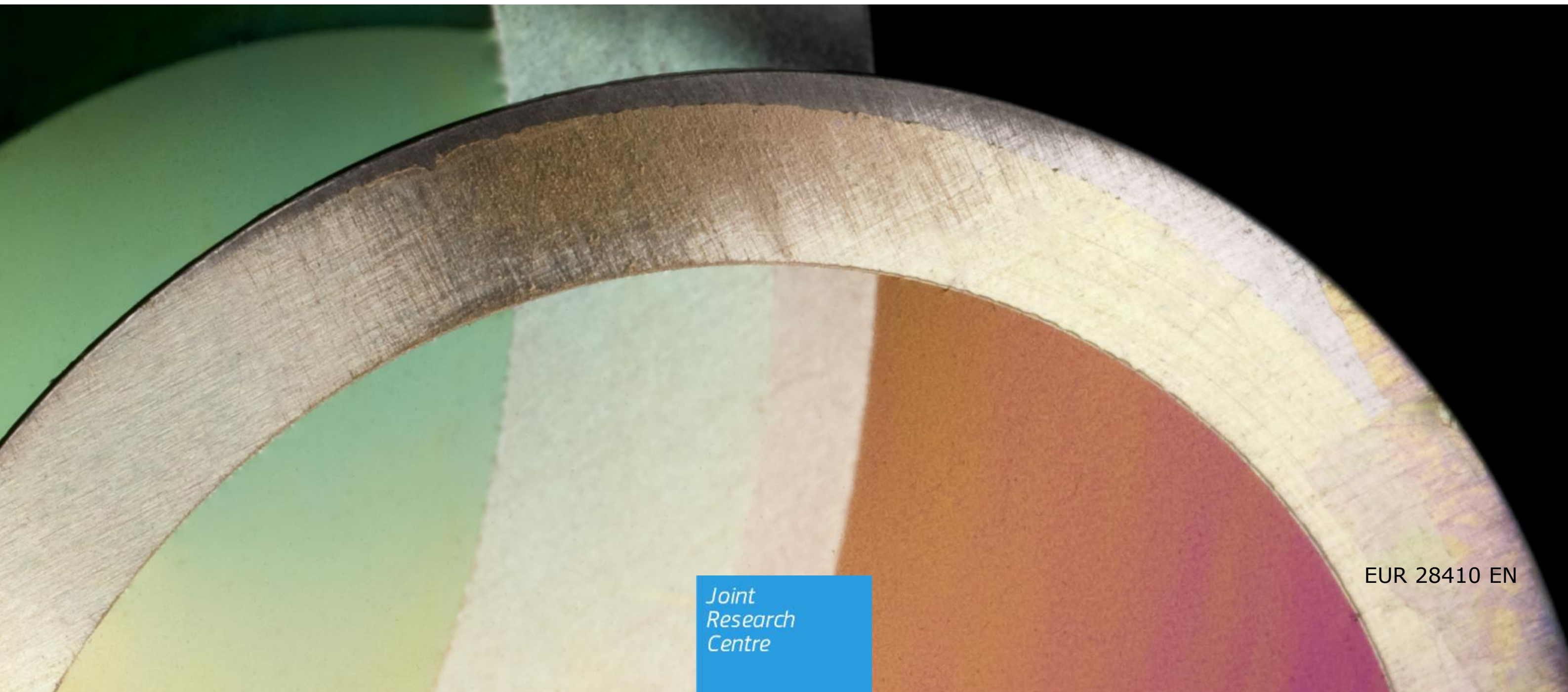

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Abstract

Much of the bioeconomic modelling work performed at the JRC has been in relation to the evaluation of proposed multi-annual management plans for fisheries. These plans increasingly require the calculation and consideration of a range of economic indicators. A key element of this work is the parameterisation of the fisheries bioeconomic models. These models require a mix of economic, fisheries and biological data. The required data may be available in different data calls making it necessary to integrate data from different data sets. This integration can be performed using the common variables between the data sets, known as transversal variables. However, the different data sets can report the data at different aggregation levels. This makes linking the data sets challenging, particularly as the evaluation of a management plan requires the economic costs and revenues to be at the same scale as the plan. Modelling approaches have been developed to overcome the different levels of aggregation

The methods developed at the JRC for linking the data and parameterising the models were applied to STECF evaluations of multi-annual management plans in the North Sea and the Western Mediterranean. When the data is of a suitable quality the method works well even when the fisheries are complicated and involve multiple species being fished by multiple gears, for example with the North Sea evaluation. However, when the data is poor, for example with the Western Mediterranean evaluation, it is not possible to perform this type of analysis. This problem will remain unless the data collection process is improved.

Even when data is not missing there is the concern that it is being recorded differently by the member states, i.e. even within the same data set the data is not consistent. For example, Member States can interpret fishing effort differently. To help ensure consistency between data sets two workshops have been held on transversal variables. One of the outcomes of these workshops is a JRC led package for R, fecR, that will allow the transparent and repeatable calculation of two different types of fishing effort.

This report presents the experiences from two STECF EWG where the JRC modelling approaches has been used and the new R package for effort calculation.

1 Introduction

This report reviews the work performed by the JRC on bioeconomic modelling. In particular it focusses on the modelling work initially performed during the WKBEM EWG in 2013 [1] and that was further developed [2] on the parameterisation of fisheries bioeconomic models using data collected under the Data Collection Framework (DCF). The methods developed have been used in STECF Expert Working Groups (EWG) for the evaluation of multi-annual management plans.

Much of the bioeconomic modelling work performed at the JRC has been in relation to the evaluation of proposed multi-annual management plans (MAPs) for fisheries. These evaluations have been carried out under the STECF. A key element of this work is the parameterisation of fisheries bioeconomic models. These models can then be used as part of an operating model (OM) when performing Management Strategy Evaluation (MSE) as part of the evaluation.

The models require a mix of economic, fisheries and biological data, for example the fishing effort and costs of fishing activity, the fishing mortality imposed on stocks and species, and the yield and revenues from each stock. The required data may be available from different data calls making it necessary to integrate data from different data sets. This integration can be performed using the common variables between the data sets (known as transversal variables), for example fishing effort and landings.

However, the different data sets can report the data at different aggregation levels. For example, data from the economic data call of the DCF is aggregated across all of FAO Area 27 and is at the fleet level, whereas the biological data is aggregated by the management area and by fishing metier. This makes linking the data sets challenging particularly as when evaluating a management plan it is necessary to estimate the economic costs and revenues at the same scales as the plan.

Modelling approaches have been developed to overcome the different levels of aggregation [2]. However, these methods are not able to overcome all of the problems with the data, for example, when there is missing data, the same variable has been recorded differently in different data sets or the data is clearly incorrect.

The modelling approach requires transversal variables to be consistent in terms of values and how they are measured and recorded. However this is not always the case [3]. Attempts have been made to standardise the collection and reporting of transversal variables [4, 5]. In particular, the workshop held in Nicosia in 2016 focussed on the calculation of fishing effort. One of the outcomes of this workshop was an R package, fecR, for calculating effort [6].

This report presents the experiences from two STECF EWG where the JRC modelling approaches has been used: the North Sea and the Western Mediterranean as well as the new R package.

2 Management plan evaluations

One of the main drivers for developing and parameterising fisheries bioeconomic models is their use in the evaluation of proposed management plans. As mentioned in the introduction this requires linking data from different data sets that may had been collected at different scales. Transversal variables is used to link the data sets.

To overcome the differences in aggregation scales, modelling is performed to estimate values at the same scale as the management plan. However, the modelling work depends very strongly on the quality of the data. If the data is missing or the transversal variables are not consistent between the data sets then it is not possible to rescale the data using modelling.

Experiences from two management plan evaluations performed during STECF EWG are presented here. The results of the evaluations are not presented (these can be found in the associated EWG reports), only the experiences of attempting to parameterise and use the bioeconomic models.

2.1 Evaluation of the proposed multi-annual plan for North Sea demersal stocks.

The plan covers all demersal stocks caught entirely or partly in the Eastern Channel, North Sea, Skagerrak or Kattegat. In particular, the evaluation focussed on stocks of cod, haddock, whiting, saithe, sole, plaice and Nephrops. The evaluation was performed in April 2015 [7].

As well as evaluating the sustainability of the stocks, the EWG was asked to evaluate a range of economic indicators for the fishing fleets including costs and income. This was particularly challenging given the mixed-fishery, multi-species and multi-gear nature of North Sea demersal fisheries.

Four models were available; Ecopath with Ecosim (EwE), Fcube, Simfish and Fishrent. These models implement very distinct concepts of the marine system: EwE is a spatial ecological model with a strong emphasis on the energy transfer across trophic levels combined with a mixed fisheries model; FCube is a mixed fisheries simulation model with a focus on technical interactions; Simfish is a spatial bio-economic model that, within the constraints of different management options, optimizes the effort allocation across fleets to get the maximum economic rent and Fishrent is similar to Simfish without the spatial component. The models covered different species assemblages and gears to allow a full picture of the fishery to be seen.

It is important to note that even though many of the models include economic considerations their aggregation levels are not always similar. FCube uses a combination of the metier definition and vessel size to approximate the economic fleet segments, while Simfish and Fishrent use the economic fleet definition. These two definitions can lead to substantially different allocation of vessels to fleets and computation of effort, in particular for the vessels that can distribute their effort to several gears throughout the year. The economic definition will allocate all the operation of those vessels to the most used gear each year, while the metier definition will split the effort across each gear, duplicating when several gears are used simultaneously.

2.1.1 The method

The FCube economic model was parameterised using the modelling approaches developed in [2]. The full method for parameterising the model can be seen in the Appendices of the EWG report [7].

The idea was to compute costs per unit of effort at the metier level of the fleet as defined in DCF level 4 (aka "gear" for shortness). This is the aggregation level used for stock assessment and forecasting and is the level required for evaluating the proposed plan. By scaling the information it is possible to add an economic component to it to the simulations and the evaluation of the plan.

The costs were computed at the metier level as a weighted average of the costs reported by Member States at the level of the so called fleet segment. Using these data a set of mixed effects models were fitted using the fleet segment as a random effect and as fixed effects: member state, year (only for variable costs), gear (metier level 4) and length-over-all. Finally a set of predictions were carried out to compute the modelled value and confidence intervals (0.95).

For this analysis to be performed properly was necessary for the data to be of sufficient quality. During the first workshop on transversal variables [4], the quality of the data was discussed and the conclusions were that each member state was processing the effort data differently. This situation had an impact on the analysis. There were two issues that had to be taken into account when using this dataset:

- Predictions shouldn't be crossed between Member States. If one needs to fill gaps in data this should be done using the same member state data.
- The analysis of costs time series should be made relative and only used for comparing between scenarios.

We call the economic aggregation of fishing operations, fleet segments, and the "biological" metier. For fleet segments the catch device is called "fishing technique", while for metiers is called "gear type".

The analysis was carried out in 3 major steps:

1. Compute the standardized economic variables (fixed costs by vessel, variable costs by unit of effort (kwday) and crew costs by euro of revenue - aka crew share) by gear type, member state, length class and year. The variables were computed as a weighted average of the standardized economic variables at the fleet segment level.
2. Fit mixed effects models using fishing technique as a random effect and as fixed effects gear type, member state, length over all class and year.
3. Use the models to predict the standardized economic variables by gear type, member state, year and length over all class.
4. Populate the FCube model with the output and perform management plan evaluations.

2.1.2 Conclusion

Given the limitations with the data described above, the approach for parameterising the bioeconomic FCube model was largely successful. A wide range of evaluations were able to performed that included some economic indicators (see the EWG report for full details). As the quality of the data improves in future data calls more accurate modelling will be possible.

2.2 Evaluation of the multi-annual plan for demersal fisheries in the Western Mediterranean

STECF were asked to evaluate a proposed plan for demersal fish stocks in the Western Mediterranean [3]. This was a complicated evaluation requiring the simulation of many scenarios for 24 stocks over 7 geographical areas. As well as reporting indicators for biological sustainability the EWG were asked to assess a range of economic indicators including Gross Value Added (GVA) and costs.

As with the North Sea case study, performing the evaluations requires the parameterisation of bioeconomic models. The intention was to use the methods described above and integrate data from different data sets using transversal variables and running models to rescale the data were necessary. Unfortunately, due to limitations in the data it was not possible to perform this analysis (see below). Nevertheless, the

EWG considered it was important to report on this subject so that future analysis can build on this attempt. The full details can be seen in the meeting report [3].

Fleets are assumed to exploit demersal resources in the case study area, where stock assessment data is assumed to be available for the main demersal stocks. Fleets are groups of homogeneous vessels for which economic, transversal and fishing mortality data are available (or can be estimated) for a number of years. In the DCF there are two concepts of fishing fleets, the 'economic' concept, which relates fleets with economic performance, in particular relates effort with costs, and the 'biological' which relates fleets with fishing power, relating effort with fishing mortality. These two concepts need reconciliation to be used in a context like the one described here.

As the management system in the Mediterranean is mainly based on effort restrictions, management measures are assumed to modify activity (limitations on average days at sea or other measure of time per vessel) and/or capacity (number of vessels or other measure of capacity, like GT or KW). Specific management measures can be directed to each fleet segment involved in the fisheries under analysis.

A measure of nominal fishing effort by fleet segment is obtained by multiplying the corresponding values of the two management variables. When the two management variables are average days at sea per vessel and number of vessels, nominal effort is the total number of days at sea by fleet segment.

The objective of the management plan is expressed in terms of a target for the fishing mortality of one or more stocks, that target being the fishing mortality at MSY. Fishing mortality cannot be directly modified by managers but through changes in the fishing activity and capacity of the fleet. To this end, a functional relationship between fishing mortality and effort variables is needed.

The estimation of total revenues in bio-economic modelling for the demersal fisheries in the Mediterranean is a known problem. Some modelling solutions suggested in models like MEFISTO and BEMTOOL use functional relationships between total revenues and revenues from assessed stocks. When the fraction of total revenues represented by the revenues from assessed stocks is quite stable over time, the remaining part of revenues (and landings) for each fleet segment can be estimated by a linear relationship. Other solutions include estimating the landings of non-assessed stocks as a linear or non-linear function of the landings of assessed stocks and multiplying by an average price for that group of species calculated on time series data.

Given the values for total revenues and variable costs, it is possible to estimate labour costs. This variable for Mediterranean fisheries is generally calculated by applying a crew share (which is generally around 50%) to the difference between total revenues and variable costs. The use of this approach is supported by the prevalence of the share contract among the working contracts adopted for the fishing sector in the Mediterranean countries.

2.2.1 Linking economics and ecology through transversal variables

To perform the economic part of the plan evaluations the methodology described in [2] was attempted. The analysis requires the linking of the economic data with the stock assessment biological data, thereby linking the costs and revenues to the stock productivity and fleet exploitation. This required the same fleet segments to be present in the data sets along with consistent landings and catches. An initial analysis was carried out to assess the data available, followed by a comparison of fleet data and finally comparing the landings by species and GSA in each dataset.

Specific shortcomings of the datasets were identified and detailed in the report. These short comings included missing economic data from some Member States in some years; missing or incorrect effort data from some Member States in some years; missing or incorrect landings and catches data from some Member States in some years.

Additionally, there were problems regarding the stability of the fleet segment and their relevant metiers. Biological data focus mainly focusing on fishing gears, while economic data are focusing on fleet segments (i.e. fishing techniques). This is important to the final stage of the analysis when the data is rescaled to the appropriate area.

The EWG compared the landings from the economic data with the total catch reported in the stock assessment used for the MSEs. The expectation is that total catch (landings + discards) from the assessments is always higher than the economic landings and that the trends are similar. A small degree of variation is acceptable, but not major discrepancies. However, comparing the trends in landings and catches by stock from the economic data and catch from STECF stock assessments revealed major discrepancies for several stocks and areas. For example, for ARA 1 and ARS 11 the landings from AER are much higher than the catch from STECF assessments. For MUT there are strong discrepancies between data sources and these depend from reporting in the economic landings of a mixture of MUX, MUM, MUT and MUR which does not match how these species are reported in the biological data. These discrepancies unfortunately meant that the modelling approach used to condition bioeconomic projections was not possible.

2.2.2 Conclusions

The EWG found consistencies and discrepancies between the catches in the stock assessments and the landings from the economic data. Some discrepancies could be due to a comparison of data originating from different data calls, to experts in the STECF EWG reconstructing different time series of discards and landings or using national datasets and different species aggregations in the biological Mediterranean data call and in the economic data. These problems prevented bioeconomic analysis from being performed. This illustrates that even the modelling method for conditioning models can work, for example in the North Sea example described above, it is necessary that the data in the different sets is compatible for the approach to work.

3 Improving measurement and collection of transversal variables for bioeconomic modelling

One of the challenges in using the transversal variables to link different data sets is that there are differences in how the same variable is collected and measured between different data sets and also different Member States within the same data set. To help address this issue two ad-hoc workshops were held, organised through PGECON, that focussed on the understanding the differences between variables and agreeing ways of standardising the data [4, 5]. These workshops tackled the issues related to the increasing need of having fisheries fleet economic data and fisheries biologic data on a level of disaggregation that would allow a proper interoperability between datasets to underpin bioeconomic modelling

A key outcome of these workshops was agreement on how fishing effort data should be calculated and reported in the different data calls. Two measures of fishing effort were considered: Days at Sea and Fishing Days. Using the modelling methods described in [2], the Days at Sea can be used to approximate the costs of fishing while the Fishing Day can be used as a measure of fishing pressure. Both are essential for bioeconomic modelling.

The fishing effort calculations have been implemented in a new package for R [6], led by the JRC. This package is available on the R package distribution system, CRAN, and is freely available for all interested parties. It can be used by experts to prepare and analyse fishing effort data in a consistent, transparent and reproducible way. The package is fully documented and has two manuals, including examples. This package is a good outcome from the workshops on transversal variables and should lead to improvements in data collection.

Attendees of the meetings have been encouraged to use the R package and feedback will be gathered to improve future releases.

4 Conclusion

The multi-annual management plans increasingly require the calculation and consideration of a range of economic indicators. This requires the development and use of bioeconomic fisheries models. Parameterisation of these models is challenging given that the required data is found in several different data sets which can be at different scales. Linking the data sets is done through the use of transversal variables.

The methods developed at the JRC for linking the data and parameterising the models was applied to STECF evaluations of multi-annual management plans in the North Sea and the Western Mediterranean. When the data is of a suitable quality the method works well even when the fisheries are complicated and involve multiple species being fished by multiple gears, for example with the North Sea evaluation. However, when the data is poor, for example with the Western Mediterranean evaluation, it is not possible to perform this type of analysis. This problem will remain unless the data collection process is improved.

Even when data is not missing there is the concern that it is being recorded differently by the member states, i.e. even within the same data set the data is not consistent, for example with fishing effort. To help ensure consistency two workshops have been held on transversal variables. One of the outcomes of these workshops is a JRC led package for R that will allow the transparent and repeatable calculation of two different types of effort.

References

[1] Ernesto Jardim *et al*., Bioeconomic Modelling Applied to Fisheries with R/FLR/FLBEIA. EUR 25823. Luxembourg (Luxembourg): Publications Office of the European Union; 2015. JRC79217

[2] Finlay Scott *et al*., P491-BioMod Deliverable 4912 Linkage of Economic and Fisheries Indicators. EUR 27564. Luxembourg (Luxembourg): Publications Office of the European Union; 2015. JRC98416

[3] Scientific, Technical and Economic Committee for Fisheries (STECF) – Evaluation of management plans: Evaluation of the multi-annual plan for the demersal fisheries in the Western Mediterranean (STECF-16-02). 2016. Publications Office of the European Union, Luxembourg, EUR XXXXX EN, JRC XXXXX, XXX pp.

[4] Cristina Ribeiro *et al*., Report of the Workshop on Transversal Variables. Zagreb, Croatia. 19-23 January 2015. A DCF ad-hoc workshop. 82pp.EUR 27153; doi 10.2788/385049.

[5] Cristina Ribeiro *et al*., Report of the 2nd Workshop on Transversal Variables. Nicosia, Cyprus. 22-26 February 2016. A DCF ad-hoc workshop. 109pp.EUR 27897; doi 10.2788/042271.

[6] Finlay Scott et al., fecR: Fishing Effort Calculator in R. package version 0.0.1. https://CRAN.R-project.org/package=fecR, 2016

[7] Scientific, Technical and Economic Committee for Fisheries (STECF) – Evaluation of management plans: Evaluation of the multi-annual plan for the North Sea demersal stocks (STECF-15-04). 2015. Publications Office of the European Union, Luxembourg, EUR 27232 EN, JRC 95959, 152 pp.

List of abbreviations and definitions

OM – Operating Model
EWG – Expert Working Group
MSE – Management Strategy Evaluation
DCF – Data Collection Framework
AER – Annual Economic Report

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